INTERACTION OF THE BLAST WAVE WITH WINGS

PART II. WAVE-TABLE STUDIES

Proposed Talk for Third Shock Tube Symposium
March 10-11, 1959
Hotel Chamberlin, Old Point Comfort, Va.

By Donald R. McFarland

N65-83301

NASA TMX 56265

In one of the large rooms of the gas dynamics laboratory at the Langley Research Center there has been for some time a small- scale spherical blast-wave facility which we have called the wave table. This blast-wave table consists of a large flat steel surface, 12 by 15 feet, over which are detonated small spherical bare high explosive charges. The spherical blast waves which were produced have proven to be very closely scaled and readily controllable laboratory versions of very large ~~high explosive and atomic~~ blasts.

Various types of optical studies have been made on the wave table, including time-resolved measurements of Mach-stem formation and growth as a function of burst height, wave attenuation due to rough surfaces, and transient flow field about bodies and wings. Because of the small scale of the bodies which have been used, the placement of pressure transducers has been generally limited to the table surface and used mainly for checks on the blast-wave pressure versus time characteristics and any wave reflections which may be present.

Because of the experience that had been gained in the use of the wave table in these types of studies, we have been involved in a cooperative program with the gust loads personnel on the study of the

Copy No.

W (1)

L

E

A

H

TMX # 56265

Myron C. Nagurney
NASA Evaluator

(1)

general problem of transient loads imposed on aircraft encountering blast waves.

An earlier investigation was made by placing a small wing model in the air stream from a low-speed free-air jet located in the blast-wave table. This air jet simulated the forward motion of an aircraft in flight prior to encounter with a blast wave. The strength of the blast wave used was sufficient to change the angle of attack from 0 to 30° during which time the optical studies of the transient flow were made. Good correlation was obtained of the movement of vortices along the surface of the wing and the movement of the pressure load peak obtained by the gust loads group from their previous flying models.

Mr. Pierce has already told you of the ground facility involving a large shock tube which is to be used for extending these studies to higher velocities. In order to gain some preliminary insight into the feasibility of this idea as well as to obtain some optical data on the transient flow occurring at the higher Mach numbers, we installed a six inch shock tube in our small-scale facility.

Our small-scale facility arrangement is shown in figure 1. The blast-wave table consists of a two-inch thick boiler plate approximately 12 feet by 15 feet, over which is detonated a small 15 to 50 gram bare pentolite charge. The shock tube tunnel was 4 feet long and 6 inches in diameter which is a one-twentieth scale of the shock tunnel just described by Mr. Pierce.

As Mr. Pierce has pointed out, this type of shock-tube-tunnel operation uses the so-called "cold flow" of the shock tube. Normally, this part of the flow is not used for testing purposes in shock-tube work. In order to minimize reflections of the blast wave with this cold jet air stream, the air in the tube is preheated by electrically heating the shock-tube wall. By obtaining the correct preheat temperature, the jet-flow temperature and density could be matched to that of the ambient room conditions, leaving only the mixing zone at the edge of the jet for possible reflection with the blast. Diaphragms for the 6-inch diameter tube were brass shim stock and were scribed in four pie sections. A remotely controlled hammer and plunger arrangement was used to burst the diaphragm at the desired pressure. Schlieren photographs were obtained at different blast flow times by the use of a variable-delay generator triggered by the blast front which then fired the schlieren spark light source.

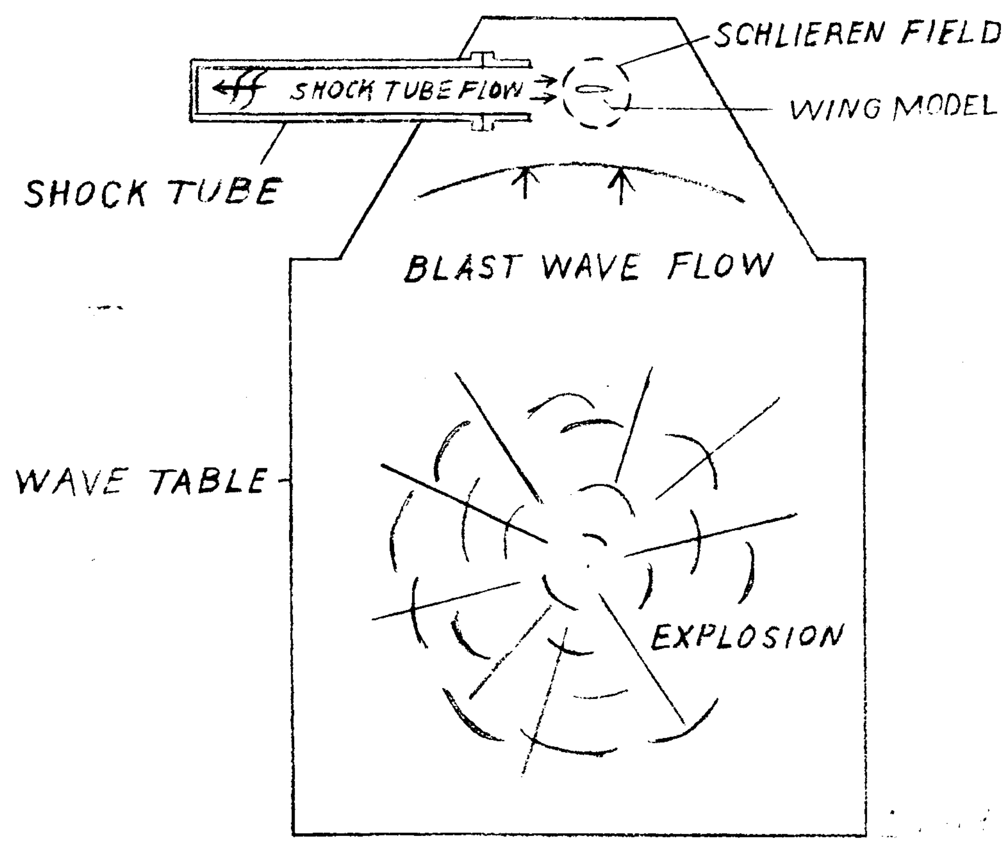
As was mentioned previously, a 0.10 Mach number steady free-air jet was used with the wave table prior to the use of the shock tube. To acquaint you with this low speed data, some Schlieren photographs of the vortex patterns are shown in figure 2. The picture at the top of the figure shows the blast flow normal to the jet flow resulting in an initial angle-of-attack change of 30°. This angle of attack, of course, decays as the blast flow decays with time. The first schlieren picture was taken shortly after blast front arrival. The second picture is in the order of 300 microseconds after blast arrival. In order to show the vortices somewhat more clearly, the model was set at a 30° angle of attack to the blast flow with no initial flow over the wing model. It must be remembered here that although the resultant flow velocity is the same immediately after blast arrival, there are some important differences to be noted for the blast alone case. There is no initial flow field about the model prior to the blast. There is no change in angle of attack with time during the blast. Both the forward and normal components of the blast velocity decay rapidly with time for the 30-degree-blast case whereas only the normal blast velocity decays with time for the steady-jet-flow case. Despite these differences there is good correlation between these two cases in relation to the vortex movements with respect to the free-stream fluid movement.

Figure 3 shows the photographs obtained using the shock-tube flow at a forward Mach number of 0.35 which is an intermediate subsonic case. In the first picture the blast front can still be seen as it has just passed over the model. The vortex regions are still distinguishable, even though the shock-tube flow is not as clean as the flow in the previous case of the free-air jet. Here again the blast flow alone at 30° angle of attack is shown for comparison.

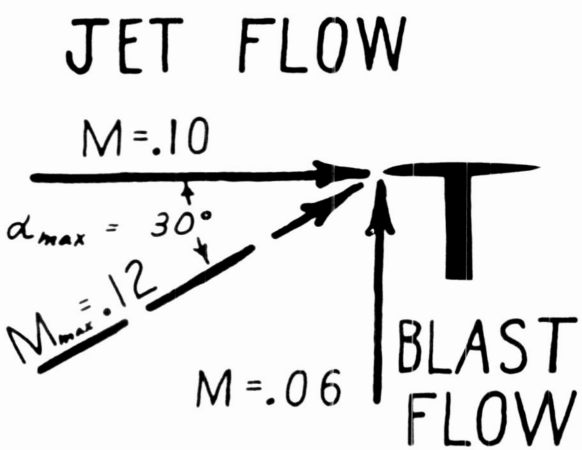
The final figure shows a high subsonic Mach number where compressibility shocks have already been set up on the wing model by the shock-tube jet flow. The identity of vortex seems to be lost in the region of the compressibility shock, although the region of disturbance is still very evident. The blast-wave front shown in the first picture appears to be even more distorted than before. This is probably due to passing through a stronger mixing zone at the edges of the circular jet flow. With the blast flow alone as in the previous case the vortices seem to hold their identity, even at these higher velocity flows.

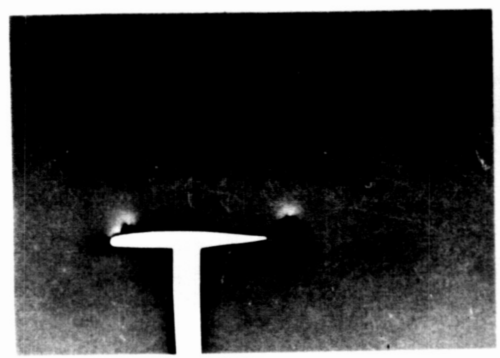
These optical studies have provided a better insight into the nature of the transient flow over a wing at different Mach numbers, when the wing encounters a blast of sufficient magnitude to suddenly change the angle of attack by a large amount. These results should prove a useful supplement to the pressure loads investigations to be carried out in the large gust loads facility.

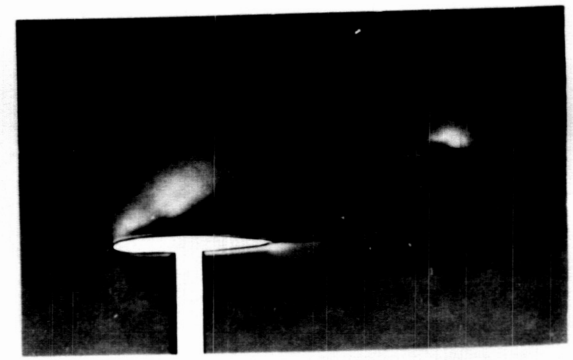
OPTICAL STUDIES OF BLAST INDUCED FLOW OVER WINGS

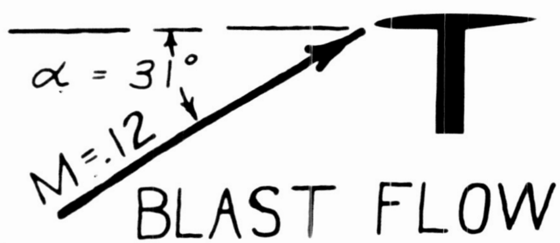


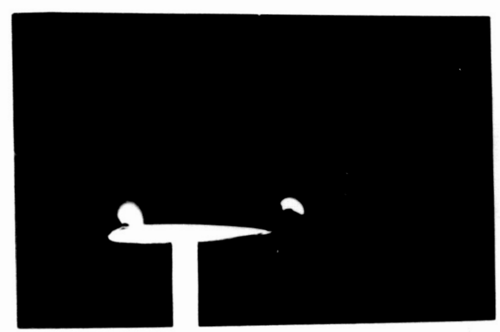
SCHLIEREN PHOTOGRAPHS

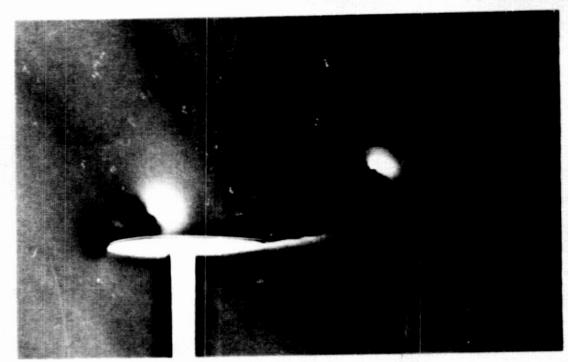




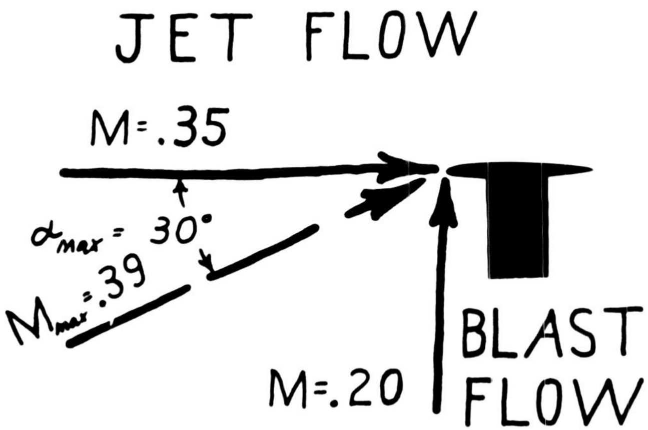


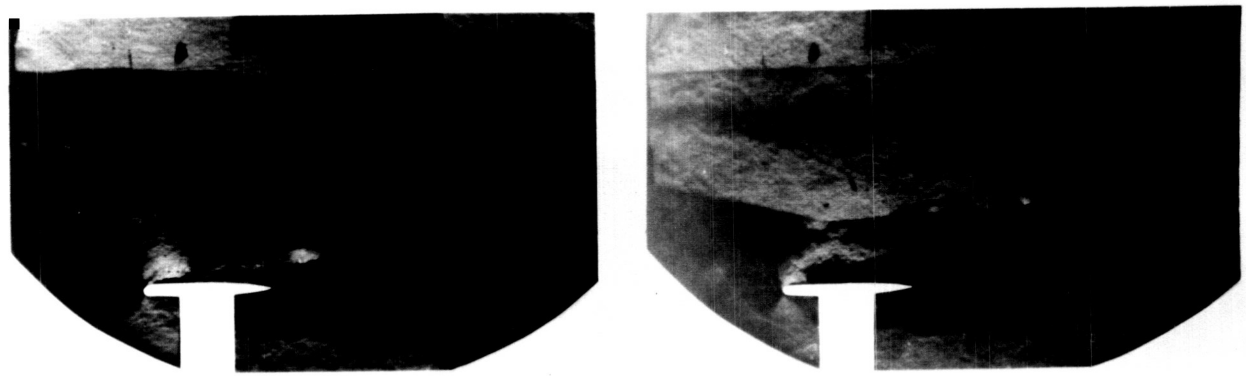


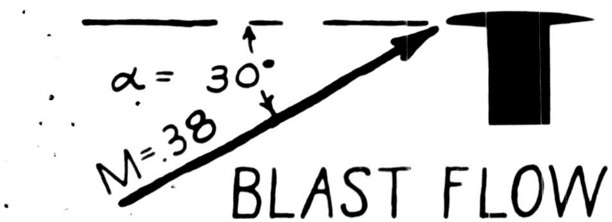


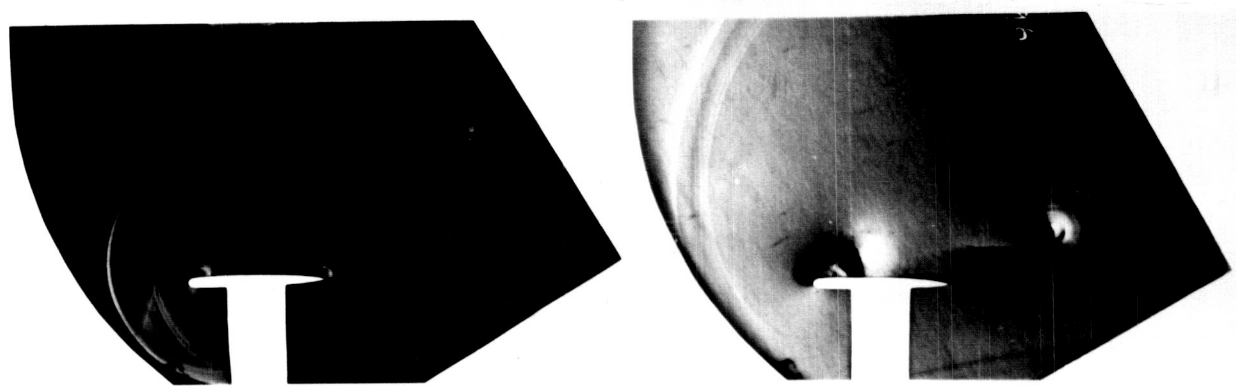


SCHLIEREN PHOTOGRAPHS









SCHLIEREN PHOTOGRAPHS